

A study on the prevalence, behavioural patterns, and risk factors of vitamin D deficiency in the population of southern Saudi Arabia

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Abstract. *Introduction:* This deficiency is one of the most common nutritional deficiencies now considered a public health problem in developed and underdeveloped countries. *Aim:* This study aims to identify the general people in the Aseer region of southern Saudi Arabia's Awareness of vitamin D deficiency, their behaviour patterns, and their knowledge of risk factors. *Methodology:* This cross-sectional community study was conducted in two cities of the Aseer Region, Abha and Khamis Mushayt. By applying a Simple random sampling technique, four Malls were selected, and two malls were in each city. The sample size was calculated by taking the prevalence from the previous study and putting on the formula $4Pq/D2$. Eight hundred eighty respondents participated in the study. Google form have been shared with the participants to collect the data. Multiple logistic regression and chi-square tests were used to analyse the significance and relationships between the variables. *Results:* Most participants knew about vitamin D insufficiency and its associated risk factors. Approximately 87.95% of respondents knew the need for vitamin D for health, and 86.82% had heard of vitamin D deficiency. 94.09% of the participants were Saudi citizens, and 52.09% were female. The majority (84.77%) said that the optimal period for vitamin D exposure in the sun is in the morning. In comparison, 54.32% said that exposed body areas, including the hands, arms, face, and legs, are necessary. Nearly 52% of respondents said their doctor had told them they were vitamin D deficient. Those who knew they had a deficiency, exhibited a favourable attitude towards taking vitamin D and adhered to their diet. *Conclusion:* By promoting appropriate and sane awareness among the populace, vitamin D deficiency can be avoided. Vitamin D understanding has grown over the past ten years in Saudi Arabia. To lessen vitamin D insufficiency in the Aseer region, however, the population's behaviour needs to be reinforced.

Key words: awareness, vitamin D deficiency, behavioural patterns, risk factor, Southern Saudi Arabia, adult population

Introduction

It has been estimated that one billion people worldwide have vitamin D deficiency (1,2). It is now considered a public health problem in developed and underdeveloped countries and one of the most common prevalent nutritional deficiencies (1). It is also the most common undiagnosed medical condition worldwide (3). In the last ten years, primary concern has increased about vitamin D status in the biomedical and health fields, and many studies were conducted examining Vitamin D use, benefits, and deficiency (04-10). Several studies have investigated the various roles of Vitamin D deficiency since its discovery, from being a simple vitamin to a steroid pro-hormone (11,12). It is well-proven that it is involved in bone and muscle development (13) and in various immune functions. It has also been reported to be linked with conditions like type 1 diabetes, Syndrome X, depression, and autism (13-15). During the first year of life, it is associated with hypocalcemic fits and Rickets (16-17). Some studies stated a higher incidence of Vitamin D deficiency among dark-skinned patients due to decreased endogenous Vitamin D synthesis and ethnocultural and environmental factors (18-22) Vitamin D deficiency is a ubiquitous problem in different age groups, with a reported prevalence of 30-80% in children and adults (23-25) and a prevalence equal to 38.6% in Saudi Arabia (25). A recent study in Nepal reported the soaring prevalence of vitamin D deficiency among adults and children in northern or southern regions. They reported that over 90% of children under five have vitamin D deficiency (12ng/ml) (26). Nevertheless, vitamin D deficiency is not limited to countries with less sunshine; in countries with plenty of sunshine, such as Greece, 47% of children aged 15-18 years and 14% aged 3-14 years also suffer from vitamin D deficiency (27). Determining a population's vitamin D status by finding the serum level could be challenging. In adult populations, early diagnosis, treatment, and appropriate preventive measures are identified as critical tools to promote health and reduce the disease burden, especially in the elderly (28). In Saudi Arabia, studies show a very high prevalence rate of vitamin D deficiency, with rates of 81% among various age groups (29). In Jeddah, the prevalence reached approximately

80% and was related to obesity, low sun exposure, inadequate vitamin D supplementation, high waist-to-hip ratio, and old age (30). Unawareness about the importance of vitamin D, its health benefits, and the prevention of deficiency among populations is believed to be one of the primary reasons for the worldwide spread of this nutritional disorder (28). This significant decrease in vitamin D levels worldwide in different age groups shows a need for more awareness about the importance of vitamin D and its resources. No such study has been conducted in the Aseer region until now, and no such data shows how many individuals were aware of vitamin D deficiency disease and their risk factors. Therefore, we have undertaken this study in the Aseer region to determine awareness and behaviour patterns regarding vitamin D deficiency and knowledge of risk factors among the general population.

Methodology

This community-based cross-sectional study was conducted in southern Saudi Arabia, i.e., the Aseer region. The two largest cities of the Aseer region were included in the study. The college ethical committee approved the current research on 9th May 2023 with reference no. ECM#2023-1604. The study was conducted in the malls where most of the public spend their leisure time. Four malls were selected by using simple Random Sampling technique, i.e., two from each city. The people who were present in the mall were selected for the study. The questionnaire was filled out on the weekends to get the maximum types of participants. They were informed and explained about the purpose of the study, and when they agreed, the questionnaire was shared with them on their mobile phones or by QR Code Scanner. Participants who were residents of the Aseer region, aged over 20 years, and agreed to participate in the study were included. Those under 18 years and non-residents of the Aseer Region and those working in the medical field, including physicians, nurses, technicians, pharmacists, dentists, and medical students were excluded from the study. Duration of the study was from 1st April to 31st August 2023. The sample size was calculated by taking the prevalence of awareness (39.3%) reported in a

prior study by Alamoudi et al., in Jeddah in 2019. By putting the values in this formula $4PQ/D^2$. $P = 39.3\%$, $Q = (1-P)$, Confidence level of 95% and allowable error of 5%, the sample size was estimated at 367. By adding 10% of non-respondents to the estimated sample size, it came out to be 434; this figure was further rounded. The final sample size was 440. To increase the participants sample size was doubled i.e. 880. The questionnaire was divided into three parts based on review of the relevant literature, medical guidelines, aim and objectives of the research, and careful consideration of expected significant outcomes. The first is for Demographic characteristics, the second consists of questions regarding Awareness and Attitude, and the third consists of knowledge of risk factors and behaviour questions. Total twenty Questions were asked for assessing participants. The collected data were given a code and then entered. Analysis was done using Microsoft Office Excel 2010 and SPSS version 16.0. Categorical information was presented in descriptive statistics like frequency, percentage, and graphs. Chi-square tests assessed the association between those with vitamin D deficiency and related risk factors as independent variables. Multiple logistic regression tests were applied. A P-value less than 0.05 was considered statistically significant.

In this study, 880 participants were interviewed; 52.95% were females, and 47.05% were males. Most of them, 50.45%, were married, and the maximum number of participants, 94.09%, were Saudi nationals. Around 50% were graduates. 18.41% were homemakers, 17.73% had occupations related to fieldwork work, and 10.91% were not exposed to the Sun as they had indoor occupations. For those between the age group of 20-29 years and among females, vitamin D deficiency is more statistically significant, as shown below in Table 1.

Awareness regarding Vitamin D Deficiency is shown in Table 2. Most (87.95%) knew vitamin D was essential for their health. About 62.27% knew the symptoms of vitamin D Deficiency, the maximum 45% felt (tiredness or respiratory diseases) due to vitamin D deficiency, followed by 25.68% said that poor growth and 19.09% said Bone fractures occurred due to Vitamin D Deficiency. About 84.77% said that early morning is the most appropriate time for exposure to the sun. Nearly 58.18% commented that the appropriate

duration for sun exposure was less than 30 minutes, and 54.32% mentioned that the hands, arms, face, and leg body parts must be exposed to sunlight. Vitamin D deficiency individuals have better understanding of the disease, as evidenced by robust statistical analyses, plausible causal variables, and acknowledging the limitations of observational studies, indicating the need for a scientifically rigorous investigation are significant.

Behaviour regarding Vitamin D Deficiency is shown in Table 3. Maximum respondents habitually went outside, usually in direct sunlight, for Vitamin D exposure. 77.05% responded that people in their families were diagnosed with vitamin D deficiency. 40% never use sunscreen, while 15.91% always use sunscreen. 88.64% want to buy and consume foods rich in Vitamin D. Around 50% have been tested for Vitamin D. 66% want to eat fortified food with Vitamin D. Nutrition: 37.73% taking the dairy/milk intake more than three times a week flowed by one to two times 32.05 %per week than less than a week 30.23. Fish intake among the participants was less. 60.23% rarely or did not take fish, followed by once a month by 30.68% of participants. 44.77% ate chicken and lamb, and 5.91% ate meat most of the time. Sunscreen usage and buying vitamin food were statistically significant.

a vitamin D deficiency

Table 4 shows the results from multivariate analyses. After adjusting for all related factors, the multivariate model revealed that for those with a Vitamin D deficiency, their awareness of disease was greater. Their behaviour regarding Vitamin D was more accurate and statistically significant. The behaviour of patients towards buying and consuming foods rich in vitamin D and taking a vitamin D test were all significant independent correlates of vitamin D deficiency. Male patients had a 1.476 times increased risk for vitamin D deficiency. Patients who use sunscreen (compared to those who do not, the reference group) have slightly lower odds of vitamin D deficiency (odds ratio = 0.8), and the result is not statistically significant ($p = 0.6$).

Discussion

In this community-based study conducted among the general population of the Aseer region, we found

Table 1. Demographic features of participant.

Question	Have a medical professional diagnosed you with a vitamin D deficiency?							P-Value
Demographic Information	Parameters	Positive and Negative Frequencies with percentage				Total		
		No (n= 418)	%	Yes (n=462)	%	(n=880)	%	
Age	20-29 years old	318	76.08	192	41.56	510	57.95	0.000
	30-39 years old	64	15.31	156	33.77	220	25.00	
	40-49 years old	32	7.66	102	22.08	134	15.23	
	> 50 years old	4	0.96	12	2.60	16	1.82	
Sex	Female	172	41.15	294	63.64	466	52.95	0.000
	Male	246	58.85	168	36.36	414	47.05	
Marital status	a widower	4	0.96	16	3.46	20	2.27	0.023
	Married	192	45.93	252	54.55	444	50.45	
	Single	222	53.11	194	41.99	416	47.27	
Nationality	Non-Saudi	26	6.22	26	5.63	52	5.91	0.792
	Saudi	392	93.78	436	94.37	828	94.09	
Education	University	196	46.89	256	55.41	452	51.36	0.000
	Diploma	44	10.53	30	6.49	74	8.41	
	Secondary	168	40.19	128	27.71	296	33.64	
	Primary	10	2.39	48	10.39	58	6.59	
Occupation	Student	186	44.50	148	32.03	334	37.95	0.000
	Housewife	38	9.09	124	26.84	162	18.41	
	Fieldwork (exposed to Sun)	108	25.84	48	10.39	156	17.73	
	Not employed	58	13.88	74	16.02	132	15.00	

that most respondents were aware of the importance of vitamin D deficiency. However, there is an unmet need among the participants regarding preventing themselves from Vitamin D deficiency and their rationale. Nearly half of the participants had been diagnosed by a doctor for Vitamin D deficiency. Analogously, a systematic review by Naseer (29) found that the prevalence of vitamin D deficiency in Saudi Arabia among different populations (adults, children, adolescents, newborns, and pregnant/lactating women) was 81.0%. Also, a study carried out by a Saudi Arabian research team Hussain AN et al (31) found that the prevalence of vitamin D deficiency was 83.6 % (19.7 % mild, 32.0 % moderate, and 31.9 % severe) when cut points of less than 75, 50, 25, and nmol/l, respectively, were used.

Another study was carried out based on a comparable study carried out by Abdelsalam M et al (32)

in the Taif region in Saudi Arabia reported that 41.8% of participants were diagnosed with Vitamin D deficiency. Thus, the deficiency varies from region to region inside the Kingdom. In our study, 86.82% had heard about vitamin D deficiency. Similarly, a study conducted by Alemu and Varnam et al (11) in England found that among their participants, 72% had heard about Vitamin D. Another critical finding in this study is that 87.95% agreed that Vitamin D is essential for our health. The study done in Jeddah by Alamoudi LH et al (04) also found that Vitamin D is essential for maintaining bone and tooth health (88.4%). In this study, a high proportion of respondents (45.0%) said respiratory illness and tiredness were the symptoms of Vitamin D Deficiency.

In contrast, in another study done in Jeddah (28), their participants also reported that respiratory illness

Table 2. Association of awareness with vitamin D deficiency of participants.

Have you ever been diagnosed with a vitamin D deficiency by a medical professional?								
Questions	Options	Positive and negative frequencies with percentage				Total		P Value
		No (n = 418)	%	Yes (n = 462)	%	(n = 880)	%	
Vitamin D is essential for health:	I don't know	64	15.31	10	2.16	74	8.41	0.000
	No	8	1.91	24	5.19	32	3.64	
	Yes	346	82.78	428	92.64	774	87.95	
Have you heard about vitamin D deficiency?	No	90	21.53	26	5.63	116	13.18	0.000
	Yes	328	78.47	436	94.37	764	86.82	
Do you know the symptoms of vitamin D deficiency?	No	234	55.98	98	21.21	332	37.73	0.000
	Yes	184	44.02	364	78.79	548	62.27	
Do you know about the following symptoms of vitamin D deficiency?	Bone fractures	114	27.27	54	11.69	168	19.09	0.000
	Poor growth	72	17.22	154	33.33	226	25.68	
	Respiratory diseases, tiredness	188	44.98	208	45.02	396	45.00	
	Anything else/ Others	44	10.53	46	9.96	90	10.23	
Appropriate time for exposure to the Sun for Vitamin D	Early morning	352	84.21	394	85.28	746	84.77	0.019
	Extremely hot times,	14	3.35	40	8.66	54	6.14	
	I don't know.	52	12.44	28	6.06	80	9.09	
The highest risk group for vitamin D deficiency	Children under five years old.	100	23.92	78	16.88	178	20.23	0.022
	Office workers	30	7.18	74	16.02	104	11.82	
	Old age > 65 years	48	11.48	52	11.26	100	11.36	
	Pregnant and breast feedings mothers	118	28.23	116	25.11	234	26.59	
	People who covered all parts of the body	24	5.74	46	9.96	70	7.95	
	I do not know	98	23.44	96	20.78	194	22.05	
What is the appropriate duration of sun exposure to obtain adequate vitamin D status?	Less than 30 minutes	236	56.46	276	59.74	512	58.18	0.109
	30-60 minutes	72	17.22	102	22.08	174	19.77	
	More than 60 minutes	12	2.87	16	3.46	28	3.18	
	I do not know.	98	23.44	68	14.72	166	18.86	
The best time to be exposed to vitamin D	3 pm - 5 pm	8	1.91	24	5.19	32	3.64	0.026
	5 pm - 7 pm	16	3.83	40	8.66	56	6.36	
	7 am - 9 am	358	85.65	348	75.32	706	80.23	
	I do not know	36	8.61	50	10.82	86	9.77	
Which parts of the body should be exposed to sunlight?	Hand and face	18	4.31	26	5.63	44	5.00	0.222
	Hand, arms, face and legs	206	49.28	272	58.87	478	54.32	
	Hands, arms and face	52	12.44	44	9.52	96	10.91	
	I don't know	116	27.75	102	22.08	218	24.77	
	Others	26	6.22	18	3.90	44	5.00	

Table 3. Association of Behaviour and Risk factors of vitamin D deficiency among participants.

Questions	Options	The doctor told you that you have a vitamin D deficiency				Total		P Value
		No (n = 418)	%	Yes (n = 462)	%	(n = 880)	%	
Behaviours related to vitamin D among participants	Do not ever think we should get vitamin D from sunlight.	68	16.27	38	8.23	106	12.05	0.036
	I do not go outside	50	11.96	66	14.29	116	13.18	
	Usually get direct sunlight	188	44.98	258	55.84	446	50.68	
	Preferred Covering body	38	9.09	38	8.23	76	8.64	
	Prefer shaded areas	74	17.70	62	13.42	136	15.45	
Anyone in your family been diagnosed with a vitamin D deficiency?	No	152	36.36	50	10.82	202	22.95	0.000
	Yes	266	63.64	412	89.18	678	77.05	
Anyone in your family took any	Do not know	68	16.27	56	12.12	124	14.09	0.000
	No	128	30.62	36	7.79	164	18.64	
	Yes	222	53.11	370	80.09	592	67.27	
Medications due to a vitamin D deficiency?								
Do you use sunscreen?	Always	52	12.44	88	19.05	140	15.91	0.000
	Never	216	51.67	136	29.44	352	40.00	
	Often	78	18.66	116	25.11	194	22.05	
	Rarely	72	17.22	122	26.41	194	22.05	
Do you want to buy and consume foods rich in Vitamin D?	No	74	17.70	26	5.63	100	11.36	0.000
	Yes	344	82.30	436	94.37	780	88.64	
	Yes	76	18.18	374	80.95	450	51.14	
Do you want to eat foods fortified with vitamin D?	I do not know	68	16.27	50	10.82	118	13.41	0.000
	It can be risky	24	5.74	22	4.76	46	5.23	
	No	66	15.79	20	4.33	86	9.77	
	There is no							
	point in doing so	24	5.74	18	3.90	42	4.77	
	Yes	236	56.46	352	76.19	588	66.82	
What is the colour of your skin?	Brown	16	3.83	16	3.46	32	3.64	0.604
	Dark brown	22	5.26	36	7.79	58	6.59	
	Light brown	216	51.67	216	46.75	432	49.09	
	White	164	39.23	194	41.99	358	40.68	
Frequency of Dairy/milk products intake	>3/week	166	39.71	166	35.93	332	37.73	0.000
	1-2 / week	98	23.44	184	39.83	282	32.05	
	Less than once a week	154	36.84	112	24.24	266	30.23	
Frequency of Eating fish	Per month	108	25.84	162	35.06	270	30.68	0.038
	Rarely/never	278	66.51	252	54.55	530	60.23	
	Weekly	32	7.66	48	10.39	80	9.09	

Questions	Options	The doctor told you that you have a vitamin D deficiency				Total		P Value
		No (n = 418)	%	Yes (n = 462)	%	(n = 880)	%	
What type of meat do you eat?	Chicken and lamb	168	40.19	226	48.92	394	44.77	0.003
	Meat	42	10.05	10	2.16	52	5.91	
	Most of them are chicken	180	43.06	188	40.69	368	41.82	
	There is none	28	6.70	38	8.23	66	7.50	
Frequency of Eating meat	>2/week	100	23.92	104	22.51	204	23.18	0.072
	2-3 times/month	188	42.58	170	36.80	358	39.55	
	Nobody	38	9.09	26	5.63	64	7.27	
	Once a week	102	24.40	162	35.06	264	30.00	

Table 4. Logistic regression analysis among participants who had vitamin D deficiency.

	B	S.E.	P Value	O.R	95% C. I for O.R	
					Lower	Upper
Age (Ref: 20-29 years old)	1.6	0.6	0.0	0.2	0.1	0.6
Sex (Ref: Female)	0.4	0.4	0.3	1.5	0.7	3.0
Marital status (Ref: Single)	3.0	1.8	0.1	0.1	0.0	1.8
Nationality (Ref: Saudi)	0.8	0.9	0.4	2.2	0.4	12.5
Occupation (Ref: working group)	0.6	0.6	0.3	1.8	0.5	5.9
Vitamin D is essential for health (Ref: Yes)	0.2	0.9	0.9	1.2	0.2	7.2
Have you heard about vitamin D deficiency? (Ref: Yes)	1.3	0.7	0.1	0.3	0.1	1.1
Whether you know the symptoms of vitamin D deficiency, or not? (Ref: Yes)	0.4	0.5	0.4	1.5	0.6	3.6
What do you know of the symptoms of Vitamin D deficiency? (Ref: Other)	2.0	0.5	0.0	7.7	2.8	21.1
The most appropriate time for exposure to the Sun for vitamin D? (Ref: In the afternoon)	3.4	1.0	0.0	28.9	4.2	201.5
Which group is most at risk of vitamin D deficiency? (Ref: Others)	0.2	0.5	0.7	1.2	0.5	2.8
The appropriate duration of sun exposure to obtain adequate vitamin D status? (Ref: More than 30 minutes)	0.0	0.4	1.0	1.0	0.5	2.1
The best time to be exposed to vitamin D? (Ref: 7 am - 9 am)	0.6	0.6	0.3	0.5	0.2	1.7
Has anyone in your family been diagnosed with a vitamin D deficiency? (Ref: Yes)	0.0	0.6	1.0	1.0	0.3	3.0
Has your family taken any medications due to a vitamin D deficiency? (Ref: Yes)	0.7	0.7	0.3	0.5	0.1	2.1
Did you use sunscreen? (Ref: Yes)	0.3	0.5	0.6	0.8	0.3	2.1
Do you want to buy and consume foods rich in Vitamin D? (Ref: Yes)	3.0	0.8	0.0	0.1	0.0	0.3
Have you ever had a vitamin D test? (Ref: Yes)	3.6	0.5	0.0	0.0	0.0	0.1
Do you want to eat foods fortified with Vitamin D? (Ref: Yes)	0.6	0.5	0.2	0.5	0.2	1.4
Constant	3.9	2.4	0.1	48.2		

Abbreviations: B: Coefficient or Beta Coefficient; S.E: Standard Error; O.R: Odds Ratio; C.I: Confidence Interval for Odds Ratio.

symptoms were of Vitamin D Deficiency (86.7%). Nearly a quarter of participants in our study they were stated that the pregnant and breastfeeding mothers' group was at the highest risk of getting vitamin D deficiency. Similarly, in a study done in Jeddah, 66.9% of the respondents identified pregnancy as a high-risk factor for Vitamin D deficiency (28). An article published by Holick, M. F. and a study by KC Chiu (33-35) stated that adding vitamin D supplements during pregnancy decreases the development of islet autoantibodies in offspring. The current study participants (84.77%) replied that the appropriate time of exposure to the sun for vitamin D was early morning. Concurrently, a study by (36) found that 85.3% of participants replied that early morning is the best time for sun exposure. Among the study participants, females were more deficient in vitamin D deficiency than males, the difference being statistically significant. Likewise, a study done by Al-Faris NA et al (37) among pregnant ladies found that approximately 50% were deficient in Vitamin D. A higher proportion of them, 47.2%, reported that they were getting Vitamin D Deficiency information from doctors.

In contrast, a study in Jeddah (28) reported that their friends made them aware of Vitamin D Deficiency. Nearly 27.95% responded that vegetables are a good source of vitamin D. (38) reported that fish liver oils are a rich source of vitamin D (250 µg/100 g). Concurrently, a study by S. Karthik, B et al., (39) stated that among their participants, around 50 % stated that a rich source of Vitamin D is fish. Of those who were deficient in vitamin D Deficiency in them, 33% started drinking milk. A study conducted by Alemu E et al (11) found that 89% included Vitamin D-rich foods such as milk, fish or eggs in their meals, whereas 11% did not included Vitamin D Rich foods.

Limitations of the study

In this study, we asked many questions about vitamin D deficiency status, its benefits, resources, symptoms, etc., and used an electronic questionnaire method in which participants were comfortable giving responses. Limitations are that the study is cross-sectional, and the sample size could have been larger.

The elders included could have been more numerous, possibly due to their lessened use of electronic gadgets. However, more community-based studies need to be conducted to raise awareness among the community.

Conclusion

This study underlines that a maximum number of participants were aware of the importance of vitamin D. Still, a maximum number of adults between the age group of 20 -29 years responded that they have vitamin D deficiency. Those spotted with Vitamin D Deficiency had more knowledge of vitamin D Deficiency risk factors, and they had positive behaviour toward decreasing deficiency. Still, around half of the participants needed to be made aware of the best source of Vitamin D, or they had to use vitamin-fortified foods to prevent Vitamin D deficiency. This gap needs to be replenished as early as possible by increasing the awareness campaigns through mass media community programs or newer interventions.

Authors Contribution: YZ, MSK, and AM were involved in the study's questionnaire development, design, and data collection. MZ, SRA, AMA, and AA were involved in statistical analysis and table formation. KM, BRN, MZ, and MFA prepared and edited the manuscript. SEM, FR and NAA undertook proofreading, final editing, and formatting. All authors have read and finally agreed to the published version of the manuscript.

Institutional Review Board Statement: The study obtained institutional ethical committee approval (ECM#2023-1604ECM#2023-1604 dated 09-05-2023) from the ethical committee of King Khalid University, Abha, Kingdom of Saudi Arabia.

Informed Consent Statement: The Informed Consent was obtained after explaining the study's objectives and ensuring the confidentiality of data to the participants.

Data Availability Statement: Data is available to the authors.

Conflicts of Interest: The authors declare that they do not have conflicts of interest.

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